FAIRY SHRIMP POPULATIONS OF NORTHEASTERN OHIO IN THE SEASONS OF 1945 AND 1946

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Throughout the late winter and spring of the years 1945 and 1946, field studies on anostracan phyllopods (fairy shrimps) were continued in Portage, Summit, Stark, and Crawford Counties of northeastern Ohio. Reports on this work for the years 1941–1944 inclusive have already been published (Dexter and Sheary, 1943; Dexter, 1943 and 1946). This paper presents the observations on seasonal and geographical distribution of fairy shrimps from a study of more than eighty pools and ponds during the fifth and sixth years of an annual survey, including a week by week life history study in two ponds throughout the entire fairy shrimp season, together with new information on ecological relationships of this group of sporadic crustaceans. Also, there is added a compilation of collecting records of the Anostraca from other sections of Ohio.

Acknowledgment is made to those who have kindly contributed specimens and records to this study. Their names are given in the paper in connection with their specific contributions. We are indebted to Dr. Folke Linder of Uppsala, Sweden, and to Dr. Edwin P. Creaser for service rendered in settling certain taxonomic problems. We thank Dr. Kenneth L. Kelley for making the collections for two weeks from the two ponds in which life history studies were in progress while the senior writer was out of the state.

Review of Field Collections—Season of 1945

In 1945, 83 pools and ponds were visited. Sixty-five of these had been studied and reported upon in previous years. Six new stations were added in Portage County and four new ones in Stark County. Eight stations, which had been established near Bucyrus in Crawford County by the junior author in 1944, were also added to the survey. All pools known to have contained fairy shrimps at any time during the previous four years were studied. Four pools were dry when visited. Twenty-three contained no specimens, but only one of these (C3) was ever known to be populated with Anostraca. Fifty-six stations yielded specimens of *Eubranchipus vernalis* (Verrill). Six of these had not contained fairy shrimps since first investigated in preceding years (two in 1941, two in 1942, and one each in 1943 and 1944). Eight of the new stations contained *E. vernalis*. Six of the eight pools containing this species in Crawford County were known to be populated with the same species when investigation was first made in that county in 1944. Five pools in the other counties (one in Portage, two each in Summit and Stark Counties) which had fairy shrimps at various times in past years, but not in 1944, had them return in 1945. Ten pools had a definite increase in abundance in 1945 over that of 1944 while only six suffered a marked decrease in abundance. The largest specimen of *E. varnalis* collected in this study to date was a female which measured 32 mm. and was collected from pond S4 on April 1, 1945.

In a previous report (Dexter, 1943), *Pristicephalus bundyi* (Forbes) was recorded from Ohio for the first time. In a critical revision of certain groups of Anostraca, Linder (1941) suggested that probably this species should be placed in the genus Chirocephalopsis, a genus which has not formerly been recorded for North America. In conversation with Dr. Linder in the summer of 1946, when he was in this country working on the phyllopod clolections of the United States

National Museum, it was learned that he is quite convinced of the need for such a change. For that reason the present paper will follow such a classification. *Chirocephalopsis bundyi* (Forbes) was not collected in Ohio after the original find in 1942 until the season of 1945 when a single specimen was collected from the original site (C7) on March 24 by Miss LeMoyne Unkefer, a student at Kent

TABLE I

SUMMARY OF FIELD COLLECTIONS OF FAIRY SHRIMPS—SEASONS OF 1945 AND 1946

P=Portage County C=Stark County
S=Summit County Cr=Crawford County

	1945				1946			
	P	S	C	Cr	P	S	C	Cr
Number of pools studied	44	12	19	8	35	13	20	15
Pools dried out at time of visit	4	0	0	0	3	0	2	0
Pools without fairy shrimps	17	3	3	0	21	6	3	0
Pools containing *E. vernalis*	23	9	16	8	11	7	15	15
New records of *E. vernalis* (first appearance known)	P8 P23 P42 P54 P90	0	C17	0	P93	0	C15	0
New stations containing *E. vernalis*	P95 P96	0	C16 C19 C20 C21	Cr7 Cr8	0	S21	C22	Cr9 thru Cr15
Pools from which *E. vernalis* disappeared	0	0	C3	0	P18 P23 P30 P37 P40 P42 P50 P55 P58 P80 P90 P96	S3 S4 S11	C6	0
Return of *E. vernalis*	P37	S3 S4	C10 C18	0	0	0	0	0
Increase in abundance of *E. vernalis*	P17 P18 P30 P55 P91	S2 S5 S12 S14	C14	0	P54	0	C9 C10 C16 C21	Cr4 Cr5
Decrease in abundance of *E. vernalis*	P40 P79	0	C2 C8	Cr4 Cr6	P8 P17 P88 P91	S1 S2 S5 S12	C7 C8 C11 C12 C14 C18	0
C. bundyi found with *E. vernalis*	0	0	C7 C18	0	0	0	0	0
E. holmani found with *E. vernalis*	0	0	C21	0	0	0	0	0

State University, and another specimen collected by the writers on April 8 from a pool (C18) several hundred yards distant from the other. This second pond was known by the junior author to contain *E. vernalis* in the seasons of 1942 and 1943 as well as in 1945, but no fairy shrimps were found there in 1944. Both specimens of *C. bundyi* were found among specimens of *E. vernalis*.

A third species of Anostraca for the State of Ohio was discovered for the first time in 1945. From a small collection of fairy shrimps taken in a shallow pool (C21) on Route 30 between Canton and Massillon on April 25, there was found a

single male specimen of *Eubranchipus holmani* (Ryder). This species, under a variety of names, has been reported previously from the following localities: New Jersey (type locality); Long Island, New York; New Haven, Connecticut; Chincoteague, Virginia; and Tiptonville, Tennessee. The taxonomy of this species has been much disputed (see Creaser, 1930), but our specimen was determined by both Dr. E. P. Creaser and Dr. Folke Linder as species *holmani* as described by Ryder, and it is the opinion of Dr. Linder that it should be assigned to the genus Eubranchipus. While Dr. Creaser at first suggested that it be placed in the genus Branchinella, it seems best to record it as *E. holmani* in view of Linder's forthcoming revision of the North American Phyllopoda.

Table No. 1 gives a summary of the field collections for 1945 and compares the results of that year with 1946. The map on page 33 of a previous report (Dexter, 1946) may be consulted for the location of many of the stations mentioned in this paper. The season of 1945 was the most favorable one encountered in six consecutive years of collecting. Every pool, except one, in which fairy shrimps were ever known to occur in past years contained *E. vernalis* in 1945. It was the only year in which all of the three species known from Ohio were collected.

Review of Field Collections—Season of 1946

During the sixth survey a total of 83 pools and ponds including nine new stations were visited. Five had dried out by the time they were reached. Thirty contained no fairy shrimps, including 16 which were known to have *E. vernalis* the preceding year. Three of these had had this species for five years, two for four years, three for three years, and four each for two years and one year respectively. Forty-eight stations contained *E. vernalis* in 1946. Two of these were inhabited for the first time since being studied over a period of two and three years respectively. All nine of the new stations added to the survey this year contained specimens. One of these (C22), however, yielded but a single specimen. The collections from seven ponds were considerably more abundant than those obtained from the same place the preceding year, while 14 ponds had a much smaller population than in 1945. Less than a dozen specimens were collected from five of these 14 stations. The largest specimen collected in 1946 was a female which measured 33 mm. and was taken from pool Cr4 near Bucyrus. Neither *Chirocephalopsis bundyi* nor *Eubranchipus holmani* was collected in 1946.

It is interesting to note that some other collectors in Ohio experienced a similar failure to find fairy shrimps as often in 1946 as in former years. However, a few also failed to find them in expected places in 1945 when the writers experienced the best year of collecting. Some of those reporting positive records in the past (see Dexter, 1946), but who failed to find specimens in the same places in later seasons are as follows: Miss Rose Azary collected *E. vernalis* on April 3, 1945, from the same pool near Painesville from which records were reported for 1944, but in 1946 she failed to find it there. Another pool in the same pasture, however, contained specimens for the first time in three years. Mr. Alfred Linscheid found *E. vernalis* to be abundant on April 10, 1945, in the Warrensville Heights swamp as in previous years. In 1946 three attempts were made to collect it from the same location, but he could find only two specimens there which were taken on March 28. Dr. William A. Dreyer failed to find fairy shrimps in the three ponds previously reported near Goshen on field trips made on February 25, 1945, February 26 and March 8, 1946. Dr. William C. Stehr found a new locality record for *E. vernalis* in Athens County in 1945 but did not find it in those pools reported for that county in past years. In 1946 he did not find fairy shrimps in any of the pools he examined including one which had been inhabited for many years up until 1943. Mr. Ernest Vickers did not find any fairy shrimps in the pools of Mill Creek Park at Youngstown during the spring of 1945 and 1946.

The sex ratio of *E. vernalis* collected in past years from Portage, Summit and Stark Counties has been reported earlier (Dexter, 1946) to average 1 male: 1.5

females. This ratio was approximately true for all samples taken in Portage and Summit Counties. A sample from some Stark County ponds taken in 1943, however, was found to have a ratio of 1 male: 0.5 female. Another sample of 169 specimens collected from these same ponds, located west of Canton, still showed a predominance of male specimens in 1946 with a ratio of 1 male: 0.8 female. During the same season a sample of 386 specimens taken from the ponds in Crawford County had a similar ratio of 1 male: 0.75 female. Apparently the sex ratio is variable from one locality to another, and at times males are more numerous than females.

In 1943 an experiment was attempted to introduce *E. vernalis* into a temporary pool which did not contain this animal. On March 25, 32 male and 68 female specimens of this species collected from pond P7 were transferred to pond P42 which contained no fairy shrimps since the survey began in 1941. One week later two specimens were collected during a cursory re-examination of the pool. That fall the field in which the pool is located was plowed and planted with winter wheat after lying fallow for several years. Water collected in the field as usual during the following spring, but fairy shrimps could not be found after a thorough sampling on two different occasions. In the spring of 1945, however, one male and one female specimen were collected there. The next year no specimens could be found. The cultivation of the field may have prevented the successful introduction of fairy shrimps. Where they have become well established, however cultivation does not seem to interfere with them. Two of the most productive pools in Crawford County (Cr5 and Cr8) are in cultivated fields.

Comparison of the Life History of Eubranchipus vernalis in Two Ponds

Pond P7 filled with rain water for the first time in 1945 on February 21. Three days later metanauplii of *E. vernalis* were collected which averaged 1.25 mm. in total length. On March 10 only a single specimen was found in the plankton samples. This measured 5.5 mm. whereas on this date during the preceding year the shrimps were only four days old and measured 2.5 mm. Subsequent collections in 1945 yielded abundant specimens until April 7 when the last collection for the season was made from this pool. After that date the water disappeared rapidly. Warmer water in 1945 than in the previous year resulted in a more rapid rate of growth, earlier maturity, and uniformity of size for adult specimens over a period of three weeks. Collections of 1944 were made until April 22, although the length of the season for fairy shrimps was the same each year, being a little more than six weeks. While the pond refilled on May 17, 1945, no second hatching of fairy shrimps was found to have taken place as occurred in May of 1943.

In 1946 pond P7 filled from melted ice in the second week of January. The first collection of *E. vernalis* was made on January 12 and averaged 2.5 mm. in length. This early hatch was destroyed in about two weeks, however, when the pool froze to the bottom and remained frozen solid for three weeks. Ferguson (1939) reported that *E. vernalis* is not found in pools in the Ontario region with a depth less than two and one-half feet because they would be frozen to the bottom during severe winters. In the Ohio region this does not hold true as we shall see. On February 14 rain melted the ice and refilled the pond. By the end of three days, *E. vernalis* had hatched again and measured 1.25 mm. On February 23 they were about the size of those collected on February 24, 1945. The water in the early season of 1946, however, was cooler, resulting in a slower rate of growth and a smaller maximum size attained by the time the pool dried out. The season of this second hatch, the only one which reached maturity, was again a little over six weeks in duration. Table No. II summarizes the life history of this fairy shrimp in pond P7 for the two years.

Pond P88 in the same pasture with pond P7 near Brimfield, also filled with rain-water on February 21, 1945. While the first specimens, collected on Feb-

TABLE II

COMPARISON OF LIFE HISTORY OF *Eubranchipus vernalis* IN POND P7 IN 1945 AND 1946

1945						1946					
Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1-5	1.0	5.9	.....	.....	Pond ½ full with coat of ¾ in. soft ice, 6-8 in. water. No fairy shrimp.
						1-12	4.4	5.4	2.5	.....	Pond ½ full. *E. vernalis* found—first record in 1946.
						1-19	0.5	5.5	3.5	1.0	3 inches ice over pond; 3-4 in. water under ice.
						1-26	.....	.....	.....	.....	Pond frozen to bottom. Ice 4-5 inches.
						2-2	.....	.....	.....	.....	Pond frozen to bottom. Ice 4-5 inches.
						2-9	3.0	5.3	.....	.....	Patches of ice slowly melting; few puddles under ice, in. or 2 deep. No fairy shrimps found.
						2-17	1.6	5.3	1.25	.....	Pond refilled on 2-14 from rain and snow. Froze over early a. m. of 2-17. *E. vernalis* hatched out for 2nd time. Collected under 1 in. of soft ice.
2-24	2.8	5.9	1.25	.....	Rain filled pond on 2-21. 1st collection in 1945. Plankton sample taken under ice.	2-23	0.5	5.5	1.75	0.5	Collected under 2 in. of soft ice.
3-3	6.8	6.0	.....	.....	None found in plankton sample. Pond overflowing.	3-2	4.0	5.9	1.50	.....	Pond flooded over. One specimen of *E. vernalis* only. Flood waters may have scattered fairy shrimps. Ice practically gone.
3-10	5.0	6.1	5.50	4.25	One specimen only collected in 2 plankton samples.	3-10	2.2	6.0	5.4	3.9	Pond fully covered with ⅜ in. of ice. Froze over 3-9 after a wk. of warm weather (50-60° F.). Many pink *E. vernalis* specimens collected. Few metanauplii also collected.
3-17	19.0	6.4	11.53	6.03	Specimens fairly numerous. Pond ½ dried up.	3-15	11.7	5.9	8.7	3.3	Pond full. Orange-pink in color. Immature.
3-26	18.3	6.7	17.55	6.02	*E. vernalis* abundant. Water level same as for 3-17. Egg sacs developed.	3-23	16.0	5.7	15.9	7.2	Pond ½ full. Eggs developed.
3-31	11.7	6.3	17.45	.....	Normal coloration for adults. Water level approximately the same.	3-29	19.5	6.5	16.3	0.4	Pond reduced to scattered puddles. Last record of *E. vernalis* in pond P7 for 1946.
4-7	15.3	6.2	17.98	0.53	Pond about two-thirds dried up.	4-5	.....	.....	.....	.....	Pond dry.
4-14	.....	.....	.....	.....	Pond nearly dried up. Scattered, shallow puddles only. No fairy shrimps.						
4-22	.....	.....	.....	.....	Pond completely dried up.						
5-26	17.2	6.2	.....	.....	Pond refilled on 5-17. 5-6 in. of water in places. No fairy shrimps.						

ruary 24, averaged the same size as those in pond P7, it seems that this initial hatching did not survive. A week later the specimens in pond P88 were no larger than those first collected indicating a second hatch had taken place. Unfortunately, none was found in the plankton samples taken from pond P7 that same day which could be used for comparison. However, on March 10 the shrimps in pond P88 were only 1.7 mm. in size as compared to a length of 5.5 mm. in pond P7. During the succeeding weeks, specimens in this pond (P88) were consistently smaller, grew less rapidly, and attained a somewhat smaller maximum size than in pond P7. They did, however, persist in the deeper pond for two weeks longer than in P7, and on the date of the last collection from that pond, the presence of immature individuals in P88 indicated that hatching had taken place there over a longer period of time. Somewhat cooler water on the average and the greater volume of water in P88 may explain in part these differences. On April 22, 1945, the last weekly collection of fairy shrimps for the season was made in pond P88. On the same date one year previous, the first collection of the season for this pond was made since it did not fill that year until April 11 and contained *E. vernalis* until May 13. Water remained in the pond in 1945 for many weeks after April 22 and the temperature did not go above the toleration limit, but the fairy shrimps disappeared soon after reaching maturity that year in this pond.

On January 12, 1946, metanauplii of 2.0 mm. size were collected. None had been found in the water under the ice a week earlier. They lived for a little more than three weeks, most of the time under ice, increased in size to 4.0 mm., and then disappeared. In this case it was not because of freezing to the bottom as it was in pond P7. Rather, the water below the ice turned yellow in color and became filled with gases of puterfaction. After thawing from warm rain on February 14 and filling several inches deeper, the pond refroze. Fairy shrimps were not found again until February 23 when a single specimen measuring 5.0 mm. was collected. Without much question this was a survival from the original hatch and was the last one seen from that group. One week later another specimen, the only one taken in several plankton samples, measured 1.2 mm., indicating a new hatch of shrimps had taken place after the polluted water had cleared. Those hatching at this time were not numerous, however, since subsequent samples were always small. Also, it appears that the second hatching took place over a period of days since the average size of the sample dropped abruptly on two occasions as the earlier hatched shrimps matured, died off, and left the immature and smaller ones still living in the pond. A similar situation was found in a population of *E. serratus* in a pond in east central Illinois (Dexter and Ferguson, 1943). Having hatched later, and living in a deeper pond which did not dry out until summer, the fairy shrimp population of pond P88 persisted for three weeks longer than that in pond P7. This second population of *E. vernalis* in station P88 paralleled very closely the life history of this species in the same pond the year previous. Table III presents the data of environmental conditions and life history of *E. vernalis* in this pond for the years 1945 and 1946.

TABLE III

COMPARISON OF LIFE HISTORY OF *Eubranchipus vernalis* IN POND P88 IN 1945 AND 1946

1945						1946					
Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1-5	1.0	5.3	.....	.....	About 5 in. of soft ice, melting around edges of pond. Free water at margin of pond. No fairy shrimps.
						1-12	4.0	5.4	2.0	.....	Pond ½ full. First record of *E. vernalis* in 1946.

TABLE III—*Continued*

Date	°C	pH	Length in MM	Growth in MM	Notes	Date	°C	pH	Length in MM	Growth in MM	Notes
						1–19	2.2	5.6	3.0	1.0	2 in. of ice over pond. About 15 in. of water below ice.
						1–26	0.0	5.3	3.5	0.5	4 in. ice. About 14 in. of water below ice.
						2–2	0.3	6.1	4.0	0.5	6 in. of ice. About 10 in. water below ice.
						2–9	1.4	5.7	.....	.....	4 in. of ice. About 12 in. water below ice. Water yellowish and has odor of decay. No fairy shrimps found.
						2–17	1.6	5.8	.....	.....	Pond thawed with warm rain on 2–14. Filled several in. deeper from rain and snow. Refroze early a.m. of 2–17 with about 1 in. of ice. No phyllopods found.
2–24	5.0	5.2 or less	1.25	.....	Rain partly filled pond (depth of 5 in.) on 2–21. Plankton sample taken under ice for most part.	2–23	1.0	5.7	5.0	.....	One specimen of *E. vernalis* collected under 2 in. of soft ice. Survival from original hatching.
3–3	6.9	5.2 or less	1.25	0	Depth has increased to 8–10 in. Pond about ¼ full. Many of the larvae have probably hatched since the previous collection.	3–2	5.0	5.7	1.2	.....	One specimen only of *E. vernalis* collected. Pond about ¾ full; ice mostly gone. recent hatching probably.
3–10	4.0	5.4	1.70	0.45	pond slightly deeper.	3–10	2.7	5.7	8.5	7.3	One specimen only collected under ⅜ in. of ice. Pond full. Froze over on 3–9 after a week of warm weather (50–60° F.). No metanauplii found.
3–17	17.5	6.1	3.72	2.02	Pond deeper (2 ft. deep).	3–15	12.2	5.5	13.9	5.4	Pond full. Specimens uncommon. Eggs developed.
3–26	15.3	6.7	13.70	9.98	*E. vernalis* abundant. Egg sacs developing.	3–23	9.0	5.5	10.5	.....	Pond ¾ full. Immature.
3–31	12.8	6.0	15.25	1.55	Egg sacs developed. Color normal for adults. Pond full (about 4 ft. deep).	3–29	20.0	5.9	11.1	0.6	Pond ⅔ full. Small population.
4–7	12.8	5.9	16.03	0.78	Water level nearly the same. Some small, immature individuals indicate a late-hatching group.	4–5	12.0	5.7	11.3	0.2	Pond ⅔ full. Eggs developed.
4–14	14.0	5.9	16.60	0.57	Water level beginning to drop. *E. vernalis* present but not numerous. Medium and adult sized individuals collected.	4–12	15.0	6.2	7.5	.....	Pond ½ full. Two specimens only collected. Immature.
4–22	10.0	6.2	13.00	.....	Pond about ¾ full. Only two specimens of *E. vernalis* collected.	4–20	16.0	6.1	13.25	5.75	Pond ⅓ full. Two specimens collected. One was being eaten by a Dytisid larva. Other was mature. Last collection of season.
4–28	12.0	5.9	.....	.....	Pond about ¾ full. No fairy shrimps.	4–27	.....	.....	.....	.....	Pond ¼ full. No fairy shrimps.
5–26	17.0	6.4	.....	.....	Pond about full. No fairy shrimps.						

Observations of Fairy Shrimps in Polluted Water

On a number of occasions relationships have been observed between fairy shrimps and their occurrence in polluted water. *E. vernalis* was found to be numerous in pond C10 west of Canton in 1942. Later that year a quantity of yellow clay was placed in the pond to fill in a portion of it. The following spring the water was heavily silted with the clay much of which remained in a colloidal suspension. Only a single specimen of fairy shrimp could be collected from this water after several attempts were made. In 1944 none could be found. The next year, with turbidity somewhat less, two were collected. By 1946 the clay had settled to such an extent that the water was somewhat clear again. That year the fairy shrimps returned in good numbers in that portion of the pond farthest from the deposit of silt where turbidity was at a minimum. In station C11, an extensive swamp-pond, voluminous inwash of heavily silted water from eroding clay banks may have been responsible for the scarcity of *E. vernalis* there in 1946. It is a common observation that when sediment is stirred up from the bottom of a pond containing fairy shrimps, they swim away from the cloud of silt. Sometimes great quantities of them will be seen swimming away at the very edge of the advancing cloud of silt. Advantage is taken of this fact in collecting them from ponds which have a bottom of fine sediments. It may be that a high concentration of silt interfers with the branchial respiration of phyllopod Crustacea.

As mentioned in an earlier section of this paper, *E. vernalis* which hatched in early January of 1946 in pond P88 lived under ice for at least three weeks. By the fourth week the water under the ice had turned yellowish and possessed a very strong odor of putrefaction. At this time the fairy shrimps disappeared before reaching a size over four millimeters. After the melting of the ice and the addition of rain-water over a period of several weeks, the fouling condition of the pond was cleared up. A new hatch of *E. vernalis* took place on or about March 2. These lived to maturity. In another case, station Cr10 was found to have abundant fairy shrimps on April 6, 1946, even though the water was yellowish and malodorous with putrefaction. Two weeks later, however, no specimens were living in this pool while they were still common in pond Cr11 nearby which showed no signs of putrefaction. Gases of putrefaction confined by a covering of ice seem to be most detrimental to the maturing stages of the shrimp. Mr. Donald S. Lacroix, of the Amherst (Mass.) High School, made a similar observation the same year. He collected numerous immature specimens of *E. vernalis* from under the ice of a pond at Cushman, Massachusetts, from December 22, 1945, until February 16, 1946. The ice was melted off by March 10, and on the 17th of the month only two immature specimens could be collected. After that date no specimens were seen, and apparently they did not reach maturity. Once the pond had lost its ice, the water was discovered to have a "strong odor of sulphur from decaying vegetation." The species was still living on April 17 in another pond a few miles away which had not suffered from putrefaction. In one of the bog ponds of the present study, C15, *E. vernalis* has never been collected in the central portion of the bog. There the growth of vegetation is rank and the surface is ice covered at the season when fairy shrimps are undergoing development. At the edge of the bog, however, where shallow scattered pools occur which lose their ice early and hence do not accumulate gases or lose all of the oxygen content, *E. vernalis* has been collected in small numbers.

While *E. vernalis* seems to be sensitive to suspended silt and to gases and depletion of oxygen through putrefaction, it is known that it can live in ponds polluted with an oil slick. Pond C21 in a rubbish dump located on Route 30 between Canton and Massillon, was covered with an oil slick during the spring of 1946, yet abundant specimens of *E. vernalis* were collected there on April 9 and 17. On the latter date the volume of the water was reduced to a tub full, but the

fairy shrimps were still abundant. It was in this one and another rubbish-filled pond (C19) that *E. vernalis* persisted the longest in the Stark County stations in the seasons of 1945 and 1946. Mr. Frederick R. Burrill of the Peabody Museum at Salem, Massachusetts, sent us some *E. vernalis* that were similarly collected on April 25 and May 9, 1946, from a dump pool which acquires each year considerable rust and oil from refuse thrown into it.

The most remarkable case of toleration of fairy shrimps to adverse physical conditions which has come to the attention of the writers is one involving the brine shrimp *Artemia salina* (L.). A sample was collected by Dr. Seville Flowers of the University of Utah from Great Salt Lake on January 16, 1945. Having lost the address to which they were to be sent, he kept the shrimps in culture in his laboratory until the following year. They were then forwarded to Kent, Ohio, in February, arriving on the 13th of the month. The specimens were shipped in a sealed glass coffee jar partly filled with salt water. Upon arrival the water was lukewarm in temperature—considerably above room temperature—completely clouded with a fine black suspension of silt, and was foul smelling with gases of decay. Mathias (1937) reported that this species will perish in temperatures over 40 degrees C. At first it did not appear that any of the brine shrimps survived, but several days later, after settlement of some of the suspended material, four specimens were found still alive. These were placed in a liter beaker where they reproduced through many generations and maintained a population of about eight to ten individuals. Fresh water species are not so hardy. They will often perish over night in such small containers as a coffee jar even though they are kept in cool, clear pond water. On one occasion the culture of *Artemia salina* was neglected so that the water was allowed to evaporate to a point where large masses of salt crystallized out on the bottom. The shrimps continued to live in the concentrated salt solution for some time. Water was later added and the culture is still living and thriving nearly three years after its collection.

Comparison of Ohio Fairy Shrimps with Those from Indiana, Michigan, and Illinois

Mr. Paul Donaldson, a student at Kent State University, discovered on April 13, 1946, a single pasture pool at Middlefield inhabited with an abundance of *Chirocephalopsis bundyi*. This was the first record of a large population of this species in the State of Ohio, and the first state record of its occurrence as the only species of anostracan phyllopod in a pool. The previous records were based upon a few individuals found mixed with large numbers of *E. vernalis* from the Canton ponds as discussed above. In the spring of 1945, Dr. Frank E. Eggleton of the University of Michigan sent some large samples of fairy shrimps collected that year near Ann Arbor. All of them were *C. bundyi*. The following spring Dr. J. Arthur Herrick, also at the University of Michigan at the time, collected fairy shrimps from many localities in the Ann Arbor region. Eight of his collections contained many specimens of this same species with a few of *E. vernalis* mixed with them. Since the collections from Ohio and Michigan were the opposite in composition, all published records and records known to the writers on distribution of the common species of fairy shrimps in the north central states were compiled for comparison. Our present knowledge of the occurrence of the three common species in that area indicates that this region includes the extremities of distribution of all three. *E. vernalis* is abundant in Ohio, much less common in Michigan and Indiana, and rare in Illinois. *C. bundyi* is rare in Ohio and Indiana, not found in Illinois, but abundant in Michigan. *E. serratus* is abundant in Illinois, rare in Indiana and not found in either Ohio or Michigan.

Additional Records of Anostracan Phyllopods Collected in Ohio

Since the publication of all known records of fairy shrimps from Ohio in the preceding reports of this survey, a number of new localities including records from five new counties have come to the attention of the writers. See Table IV.

TABLE IV

New Records of Anostracan Phyllopods Collected in Ohio

I. NEW COUNTY RECORDS

County	Collector	Location	Species	Notes
Geauga	Paul Donaldson	Middlefield	*C. bundyi*	Collected in abundance 4-13-46 from a single pasture pool. Not found in similar pools nearby.
Ashland	C. H. Kuehnle, Lincoln High School, Canton	Miflin	*E. vernalis*	Four specimens collected in a shallow field pond 3 miles east of Miflin on 4-19-46.
Hardin	Carl Vernard, Ohio State University	Mt. Victory	*E. vernalis*	Common in a woodland pool on 3-17-45, 1½ miles northeast of Mt. Victory.
	R. A. Dobbins, Ohio Northern Univ.	Ada	*E. vernalis*	Occur commonly each year in a small pond 3½ miles northeast of Ada, and in a swamp pond ¾ of a mile southwest of Ada. Collections from both made 3-25-45 and 4-8-45.
Preble		Jackson Township	*E. vernalis*	Collected in April of 1944 by a student at Miami University. Reported by Dr. N. T. Mattox.
Washington	H. R. Eggleston, Marietta College	Marietta	Unknown	Specimens collected for many years in a swamp between Green and Seventh Streets in Marietta, and in a temporary pool at Squaw Hollow, 3 miles west of city.

II. NEW RECORDS FROM COUNTIES PREVIOUSLY REPORTED

Mahoning	Shirley Williams	Canfield	*E. vernalis*	Abundant on 3-24, 25-45 in 2 small pools and one swamp pond.
Cuyahoga	Charles O. Masters	Cleveland	*E. vernalis*	Collected in abundance every year between 1932-41 in a hog wallow on East Forty-ninth Street near Canal Road.
Wayne	R. V. Bangham, College of Wooster	Wooster	*E. vernalis*	Collected from a pool on farm of Prof. James Anderson 4-20-46, 2 miles west of Wooster. Previous record from here reported as species unknown.
		Rittman	*E. vernalis*	Collected by school boys 4-15-46 from a temporary pool northeast of Rittman.
Marion	Carl Venard	Marion	*E. vernalis*	Collected 3-17-45 from several pools 1 mile southwest of Marion in a pasture. Not numerous. First determined specimens from this county.
Mercer	Clarence F. Clark, Ohio Div. of Conser. and Nat. Resources	Granville Township	*E. vernalis*	Collected 4-2-42 from a temporary pool, and from a woodland pool in section 19 on 3-18-45.
Auglaize	Clarence F. Clark	Jackson Township	*E. vernalis*	Collected 4-3-46 from a woodland pool in section 7.
Delaware	W. F. Hahnert, Ohio Wesleyan Univ.	Delaware	*E. vernalis*	Small collection made 3-20-46 from overflow pond of Olentangy River.
		Kilbourne	*E. vernalis*	Large collection made by a student 3-24-46 from a field pond northeast of Kilbourne.
Athens	William C. Stehr, Ohio University	Chauncey	*E. vernalis*	Small numbers collected from a temporary pool along U. S. route 33, northeast of Chauncey, on 4-4-45.

Collecting records have now been reported from 28 counties exclusive of the four studied in some detail in this survey. Thus, 32 of the 88 counties are known to contain definite locality records of fairy shrimps. Nine new localities for previously reported counties are also listed in the table. All of those with known

determination of species are for *Eubranchipus vernalis* except the one from Geauga County which is for *Chirocephalopsis bundyi*. This species, which has also been collected in small numbers mixed with *E. vernalis* populations, and a single specimen of *E. holmani* collected with *E. vernalis* as discussed earlier in this paper, brings the state list of species to three. Determinations of the species were made by Dr. Folke Linder, Dr. E. P. Creaser, Dr. N. T. Mattox, Dr. William C. Stehr, and the senior writer.

SUMMARY

1. Field studies on the occurrence and distribution of fairy shrimps in Portage, Summit, Stark, and Crawford Counties in northeastern Ohio were continued in the winter and spring seasons of 1945 and 1946.

2. Crawford County was added to the annual survey area after preliminary collecting there in 1944.

3. The populations of 1945 and 1946 are compared regarding new appearances, reappearances, disappearances, and fluctuations of abundance from year to year.

4. The season of 1945 was the most successful season during the six years of the survey. Only one pool of those known to be inhabited in former years failed to contain *E. vernalis* in 1945.

5. Three species of anostracan phyllopods were collected in 1945, namely: *Eubranchipus vernalis*, *Chirocephalopsis bundyi* (formerly known as *Pristicephalus bundyi* and *E. bundyi*) and *E. holmani*. The last named is reported from Ohio for the first time.

6. Only one species, *E. vernalis*, was found in 1946 in the regular survey ponds, and this species was not as commonly found as in the preceding year.

7. The life history of *E. vernalis* in two ponds is tabulated in detail for 1945 and 1946. Comparisons are made between them each year and between their populations of 1945 and those of 1944.

8. The sex ratio of *E. vernalis* from the new ponds in Crawford County was 1 male: 0.75 female, similar to the ratio in ponds near Canton in Stark County, but unlike the 1: 1.5 ratio usually found in Portage and Summit Counties.

9. *C. bundyi* was found in abundance, and was the only fairy shrimp present, in a pool in Geauga County in the spring of 1946. This was the first such record for the state.

10. *E. vernalis* was eliminated from ponds in which colloidal clay and excessive gases of putrefaction were present. Oil slicks, on the other hand, did not interfere with populations of this species in several cases observed.

11. The three common species of fairy shrimps in Ohio, Michigan, Indiana, and Illinois are compared in regard to their distribution and relative abundance.

12. Five new county records of Anostraca and additional records in eight other counties are recorded for the State of Ohio. Thirty-two of the 88 counties in the state have now been reported with positive records of fairy shrimps.

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